Saskatchewan's Mineral Resources
Lesson: Core Sampling and Ore Deposits

Overview
Students will explore two of the methods of ore deposit location, the airborne magnetometer survey and core drilling. Students will identify a primary target through the airborne survey and follow-up with a drill program. Core samples will be checked for mineralization. Presence of mineralization and width of mineralization will be recorded on the ore body map. Students will then determine the extent (Grade 4), approximate area and volume of the ore body (Grade 7, ES30), draw and correlate cross-sections (Grade 7, ES30) and create 3D models (ES30).

Source: This lesson has been modified from the SMA Teachers Resource Unit.

Duration: One class

Materials: (enough for 15 pairs)

- Two or more colors of play dough one should be red. (commercial or home-made)
- 2 4-5 cm long pieces of large diamet drinking straws
- Wooden dowels or skewers that will fit inside the straw and is longer than 2 inches
- 3 Graph paper labeled (Ore Deposit Grid)
- Core Log Table
- Examples
- Piece of cardboard to fit under the graph paper
- One small magnet
- One magnet on a light string (airborne magnetometer)
- Pencil
- Calculator/cell phone/i-pod
- Rulers
- Place mat

Notes to Teachers: Although this activity correlates with the Grade 7 curricula, it is a fun activity for grade 4 students to introduce the topic of how we know what is in the ground under our feet. It is also a good introductory activity for the ES 30 course and the drawing of 2D diagrams and 3D models.

Instructional Methods: Modelling, Simulation

Learning Outcomes and Indicators

Grade 7 Earth's Crust and Resources

EC7.2 Identify locations and processes used to extract Earth's geological resources and examine the impacts of those locations and processes on society and the environment.

f. Provide examples of technologies used to further scientific research related to extracting geological resources (e.g., satellite imaging, magnetometer, and core sample drilling).

g. Evaluate different approaches taken to answer questions, solve problems, and make decisions when searching for geological resources within Earth (e.g., trial-and-error prospecting versus core sampling).

k. Research Saskatchewan careers directly and indirectly related to resource exploration

Earth Science 30

ES30-LS1 Analyze surface geography as a product of weathering, erosion and mass wasting.

h. Apply mapping techniques such as creating and interpreting topographic profiles and translating between 2-D surface maps/cross-sections and 3-D box diagrams to represent surface geographical features.

ES30-LS3 Investigate the processes and technologies used to locate and extract mineral resources and fossil fuels locally, provincially and globally.

h. Recognize the importance of obtaining core samples to examine the physical characteristics and geochemistry of potential ore bodies and natural resource deposits.

Source: Saskatchewan Evergreen Curriculum

Other:

- Students will determine the area and volume of the "ore deposit".
- Students will use the information from drill logs for each drill core and will create a 2D cross-section of the "ore deposit".

- Students will use the 2D cross-sections to create a 3D model of the "ore deposit".

Big Picture Questions

1. How do they find mineral deposits in Saskatchewan?

Background Information

When a company is looking for mineral deposits, magnetic surveys play an important role as many deposits are often associated with magnetic minerals. When the company has identified a potential area with a good geophysical signature (magnetic high), good mineral values in rock, soil and stream sediment samples, the Geologists then need to know what is underground. Digging up huge areas of land is not an option open to them. Instead they use drilling machines to extract "core" samples. The "cores" can then be analyzed to determine if the underlying rocks contain any valuable minerals.

Drill core Northern Saskatchewan.
Source: K. Grapes Yeo

Diamond drill program at Fort a La Corne Saskatchewan.
Source: Saskatchewan Mining Association

Vocabulary

ore	magnetic survey
drill core	core logging

THE ACTIVITY

Teacher Preparation:

1. Prepare play-dough:
Play dough recipe: Combine 1 cup of flour, ¼ cup of salt, and 2 tablespoons cream of tartar with 1 cup water, 2 teaspoons food colouring and 1 tablespoon oil in a saucepan. Cook and stir 3-5 minutes, or until it sticks together in a ball. Knead for a few minutes on a lightly floured surface. Store in an air-tight container.

2. Set up stations:
   - At each station have three sheets of graph paper, 2-3 colours of play dough, two 4-5 cm straws, one dowel or skewer, ruler, one magnet, one magnet on a string (magnetometer).
   - Have students work in groups of 3.

Motivational Set (5 minutes)

1. Ask the students if they know what an ore body is? Explain that an ore body is a large deposit of minerals that can be mined for a profit. Geologists are looking for these deposits during the "exploration" stage of mining development.

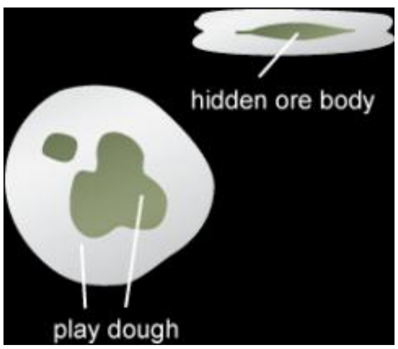
2. Explain:
The exploration phase involves identifying a target, staking a claim, mapping the geology, running geophysical surveys (such as a magnetometer survey, looking for magnetic minerals in the rocks which may or may not be associated with the mineral you are looking for) and locating targets to drill. Drilling occurs to collect core samples, which are "logged" noting the minerals present and length of mineralized rock. Samples are then taken and sent away to determine the chemistry. All of this information would assist the mining company in determining if the ore body is rich enough to support a profitable mine.

3. Explain that the red play dough represents the ore (the mineral we want to mine) the other colours of play dough are the surrounding rock that we do not want to mine. It is the waste rock.

Activity:

1. Have students label the three graph paper sheets a) "**Name"** ***Ore Deposit*****,** b) "Name" ***Ore Deposit Answer Sheet,*** c) " Name" ***Ore Deposit Plotting Sheet*****.** *For example: Bonanza Ore Deposit and Bonanza Ore Deposit Answer Sheet. They will put the name of the ore body they receive on the top of their Plotting Sheet. E.g. Eldorado Ore Deposit Plotting Sheet.*

2. Place the graph paper titled Ore Deposit Sheet on the cardboard. *(This gives it some strength and prevents students from looking under the paper to see where the ore deposit is located).* Have each group build an ore body using the red play dough, on the ***Ore Deposit Sheet***. Do not extend beyond the rectangle. Keep the coordinates visible. *(Students will use these coordinates to plot their drill hole locations.)* Start by placing the magnet at the base of the "ore deposit". Cover the magnet with red play dough and build the "ore deposit". The ore body does not need to be flat.



3. Each group should prepare a map of the outline of their "ore deposit" on the ***Ore Deposit Answer Sheet*** graph paper and give these to the teacher.

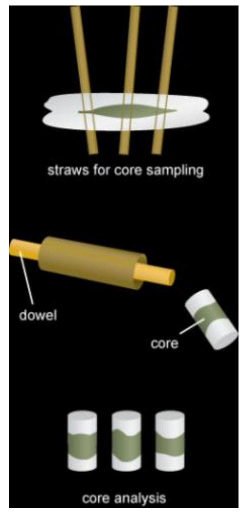
4. Next, each group will spread the "waste rock" color on top of the whole structure, extending to the edges of the rectangle. They should end up with a structure where only the waste rock color of play dough can be seen from the top and the edges. The ore body play dough color or shape should not be visible at all. *Students may use more than two colours of play dough to represent different rock units. Keep the ore deposit as red. The final surface does not need to be flat. Students can create hills and valleys.*

5. Switch the "ore deposits" with another group.

IMPORTANT: Do not let the students look underneath the paper, pass the ore deposit model along with the cardboard "place mat".

6. Magnetometer Survey. Within each group students will take turns hanging the magnet over top of the field area to try to locate the magnetic high associated with the ore deposit. This will help the students determine the area to start their drill program.

7. Once an area is identified, students start their drilling program by taking core samples. Have the students use rulers to position their drill core (A 12, DD 24 etc.). Core samples are collected by pushing the straw straight down into the play dough structure, pulling it up, poking the core sample out with a stick and examining it.



Use the grid squares and associated numbers and letters on the axes of the graph paper to accurately locate the position of the core samples on the graph titled ***Ore Deposit Plotting Sheet.*** For example K12.

8. Have the students measure the various coloured dough and record in the ***Core Log Table*** (see Examples). *When geologist log core on a drilling program they fill out the information on a Core Log. These days most geologists enter their data directly into a digital spreadsheet or table.*

9. Record ore thickness on the ***Plotting Sheet*** of graph paper (E.g. 1 cm). If no ore body color is visible, enter 0 in the grid square.

10. Have groups continue sampling until they think they have enough information to map out the shape of the ore body.

11. Record the number of core samples taken.

12. Draw an outline of the shape of the ore body on the ***Ore Deposit Plotting Sheet*** of graph paper and compare to the answer sheet.

Grade 7+

13. Count the number of full and partial grid squares occupied by the ore body to calculate the area (cm^2) of the ore body. Count each partial grid square as one-half of a square.

14. Determine the approximate volume (cm^3) of the ore body using an average of the depth measurements recorded from the core samples.

15. Follow-up with Question Sheet.

Earth Science 30 (Grade 7 Optional)

16. Draw 2D cross-sections and correlate the rock/ore units.

17. Use the 2D cross-sections to create a 3D model. (This can be done by hand (See example) or using a computer program.

Safety:

Play-dough should be thrown out after each activity.

Assessment Method and Evidence

✓ Hands on Activity

- Students will take on the role of an exploration geologist during an exploration drilling program.
- Students will be able to describe how deposits with magnetic minerals can be located using a magnetic survey.
- Students will be able to explain that using a magnet represents the technology used in a geophysical survey to find ore deposits associated with the minerals magnetite.
- Students will be able to explain that by drilling holes into the ground mining companies can learn what is underground, if there are any mineral deposits, and how large the deposits are.

Grade 7 +

- Students will be able to calculate the area and volume of their ore deposit
- Students will create a 2D representation of the ore deposit and be able to correlate the extent of the ore zone and other rock units between the drill holes.
- Students will use the 2D cross-sections to create a 3D model

✓ Discussion Questions

- Students will determine the most effective approach taken in their drilling plan and will be able to determine the most advantageous path to take when searching for geological resources using a magnetometer survey and diamond drilling as tools.
- Students will suggest reasons for the importance of 3D diagrams in the Exploration and mining for minerals resources.

Resources

What is Core Drilling? Available at:
www.youtube.com/watch?v=3VQeqw2wWWY

Drill Core section views:

Fission Uranium Patterson Lake South CoreBox #D View
Available at:
http://www.fissionuranium.com/project/pls/

Foran Mining Bigstone Project 2D Cross-sections
Available at: www.foranmining.com/s/Bigstone.asp

Vocabulary

Core logging: When geologist study the drill core the take notes and record their findings on a table called a core log. The act of studying, sampling and recording the data is called core logging.

Drill core: This is the rock cylinder removed from the ground during diamond drilling.

Magnetic Survey: The Earth acts as a giant magnet and influences minerals that are magnetic or may be magnetised, particularly objects containing iron. Magnetometers measure changes in the strength of a magnetic field. Magnetic surveys may be undertaken from the air or on the ground. The data are presented as a magnetic map using computer technology. This information can be used to help find mineral deposits associated with magnetite. Magnetic surveys can also help map geological units and faults

Ore: Ore is rock that contains important minerals including metals. The ore is extracted through mining and processed to extract the valuable element(s). Ore contains minerals that can be mined at a profit.

Core Log Table

Drill hole #	Coordinates (E.g. K - 12)	Ore present Y or N	Thickness of Ore zone (mm)	Description: Include thickness of other rock units.	Drawing
1					
2					
3					
4					
5					

Drill hole #	Coordinates (E.g. K - 12)	Ore present Y or N	Thickness of Ore zone (mm)	Description: Include thickness of other rock units.	Drawing
6					
7					
8					
9					
10					

Questions

1. As you look at each core write in your Core Log how thick each section is. Show on the map how thick the ore zone is for each drill hole.

2. Draw a map (on the graph paper) of the location of the "ore deposit."

3. Describe the appearance of the "ore deposit".

   a. Is it flat? Is it on an angle? Is there more than one ore body?

   b. Count the number of full and partial grid squares occupied by the ore body to calculate the area (cm^2) of the ore body. Count each partial grid square as one-half of a square.
      Area = ____________________

   c. Have you completely defined your ore deposit (have you found all the edges) or do you need to go back and drill some more holes? Where would you put your next holes (give the locations E.g. K12, B6)

   d. Determine the approximate volume (cm^3) of the ore body using an average of the measured thickness of the ore zone, recorded from the core samples

      Average thickness of ore body: _________________

      Volume: ______________________________

4. Using the plot of your drill holes and the information in your **Core Log**, draw a NS and an EW section through your ore body. To do this draw a straight line connecting several of your drill holes. Create a "cross-section" through those holes (*this is a map looking from the side into the earth much like looking at a slice of cake from the side*). Refer to the ***ORE DEPOSIT Section Location*** and ***Drill Core Example Sections*** diagrams. (Go to Foran Mining at: http://www.foranmining.com/s/Bigstone.asp , Scroll to the bottom of the page to see 2D cross sections.)

5. Correlate the rock units from drill hole to drill hole. (Draw a line from the top of the ore unit to the top of the ore unit in the drill hole beside. Do this for all the units). If you colour in the units it is easier to see the geology and the dimensions of the ore body. See example of Section H – $H_{1.}$

6. Create a 3-D diagram of your "ore body". (See *3D Paper Example* and check out an Interactive 3D section at: http://www.fissionuranium.com/project/pls/)

7. Why is it important to have a 3 dimensional diagram of the ore deposit and not just a 2 Dimensional map?

Answers

1. As you look at each core write in your Core Log how thick each section is. Show on the map how thick the ore zone is for each drill hole.

2. Draw a map (on the graph paper) of the location of the "ore deposit."

3. Describe the appearance of the "ore deposit". Ore bodies will vary.

   a. Is it flat? Is it on an angle? Is there more than one ore body?

   b. Count the number of full and partial grid squares occupied by the ore body to calculate the area (cm^2) of the ore body. Count each partial grid square as one-half of a square.
      Area = ___________Answers will vary_________

   c. Have you completely defined your ore deposit (have you found all the edges) or do you need to go back and drill some more holes? Where would you put your next holes (give the locations E.g. K12, B6) Answers will vary

   d. Determine the approximate volume (cm^3) of the ore body using an average of the measured thickness of the ore zone, recorded from the core samples

      Average thickness of ore body: _________________ Answers will vary

      Volume: ______________________________ Answers will vary

4. Using the plot of your drill holes and the information in your ***Core Log***, draw a NS and an EW section through your ore body. To do this draw a straight line connecting several of your drill holes. Create a "cross-section" through those holes (*this is a map looking from the side into the earth much like looking at a slice of cake from the side*). Refer to the ***ORE DEPOSIT Section Location*** and ***Drill Core Example Sections*** diagrams.

5. Correlate the rock units from drill hole to drill hole. (Draw a line from the top of the ore unit to the top of the ore unit in the drill hole beside. Do this for all the units). If you colour in the units it is easier to see the geology and the dimensions of the ore body. See example of Section H – H_1. .

6 . Create a 3-D diagram/model of your "ore body". *See example of #D "fence" diagram. Encourage students to use lines that are further apart. Students can do infill drilling to fill in open spaces in their 3D drawing/model.*

7. Why is it important to have a 3 dimensional diagram of the ore deposit and not just a 2 Dimensional map?
   - *Geologists are better able to visualize where to extend their exploration drilling in the search for more ore.*
   - *Mining engineers need to know the shape and volume of the ore body to determine if it is large enough to mine, as well as how to design the mine plan.*

_______________ ORE DEPOSIT _______________

Number of Drill Holes:___

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	Aa	Bb	Cc	Dd	Ee	Ff	Gg	Hh	Ii	Jj	
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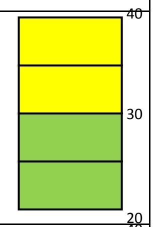
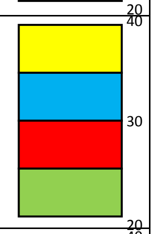
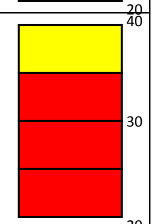
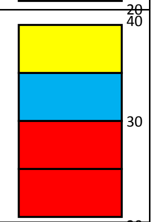
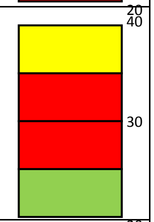
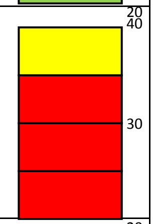
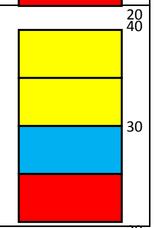
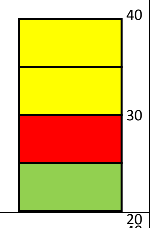
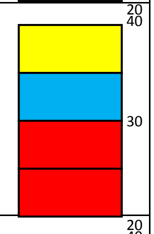
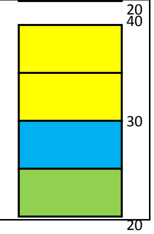
EXAMPLES

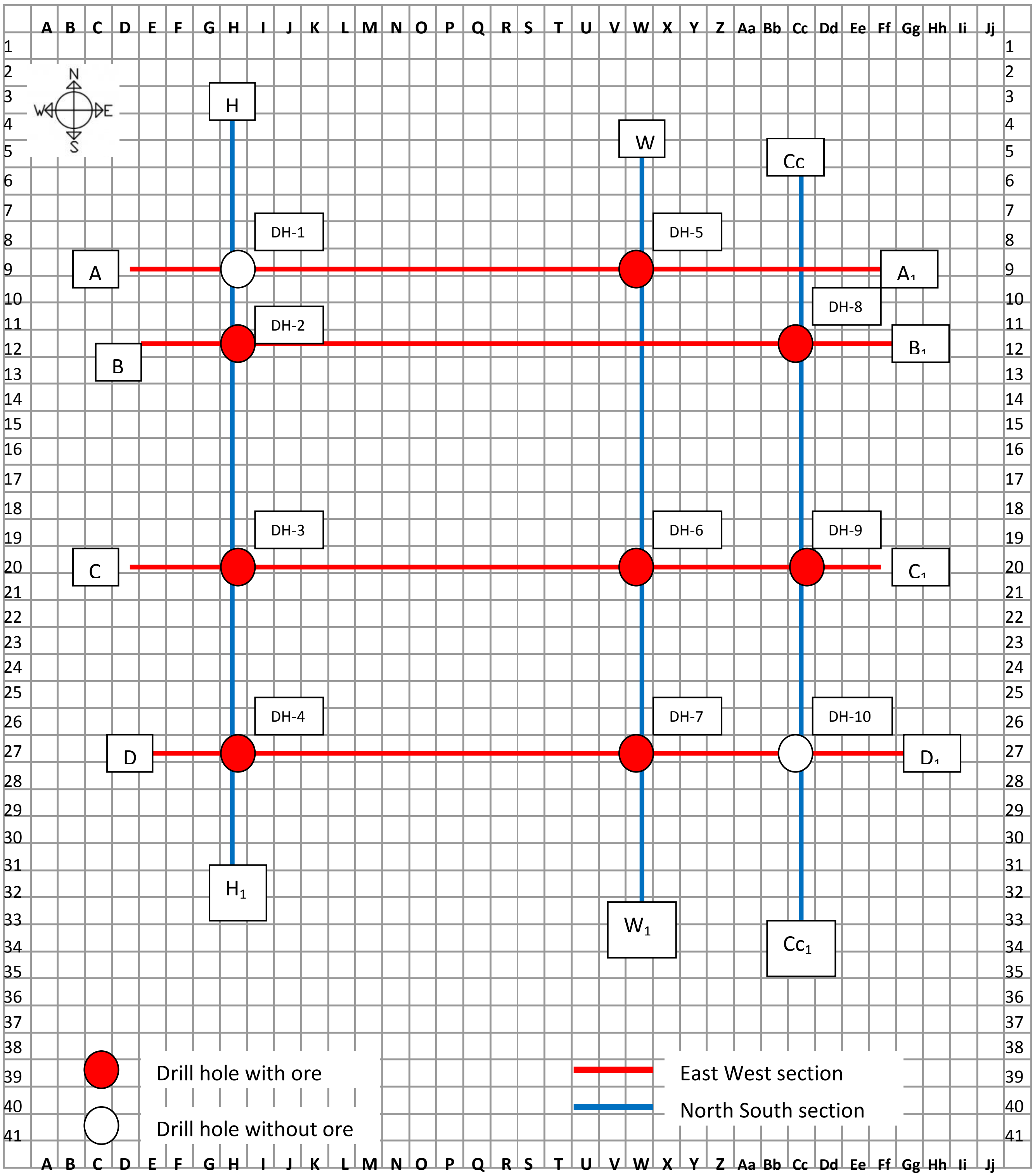
Drill Log Example

Drill hole #	Coordinates (E.g. K - 12)	Ore present Y or N	Thickness of Ore zone (mm)	Description: Include thickness of other rock units.	Drawing
1	H-9	No	0	Green rock: 20 mm Red 'ORE' rock: 0 mm Blue rock: 0 mm Yellow rock: 20 mm	
2	H-12	Yes	10	Green rock: 10 mm Red 'ORE' rock: 10 mm Blue rock: 10 mm Yellow rock : 10 mm	
3	H-20	Yes	30	Green rock: 0 mm Red 'ORE' rock: 30 mm Blue rock: 0 mm Yellow rock : 10 mm	
4	H-27	Yes	20	Green rock: 0 mm Red 'ORE' rock: 20 mm Blue rock: 10 mm Yellow rock : 10 mm	
5	C-9	Yes	20	Green rock: 10 mm Red 'ORE' rock: 20 mm Blue rock: 0 mm Yellow rock : 10 mm	
6	C-20	Yes	30	Green rock: 0 mm Red 'ORE' rock: 30 mm Blue rock: 0 mm Yellow rock : 10 mm	
7	C-27	Yes	10	Green rock: 0 mm Red 'ORE' rock: 10 mm Blue rock: 10 mm Yellow rock : 20 mm	

8	**Cc-12**	**Yes**	**10**	**Green rock:1 0 mm** **Red 'ORE' rock: 10 mm** **Blue rock: 0 mm** **Yellow rock : 20 mm**	
9	**Cc-20**	**Yes**	**20**	**Green rock: 0 mm** **Red 'ORE' rock: 20 mm** **Blue rock: 10 mm** **Yellow rock : 10 mm**	
10	**Cc-27**	**No**	**0**	**Green rock: 10 mm** **Red 'ORE' rock: 0 mm** **Blue rock: 10 mm** **Yellow rock : 20 mm**	

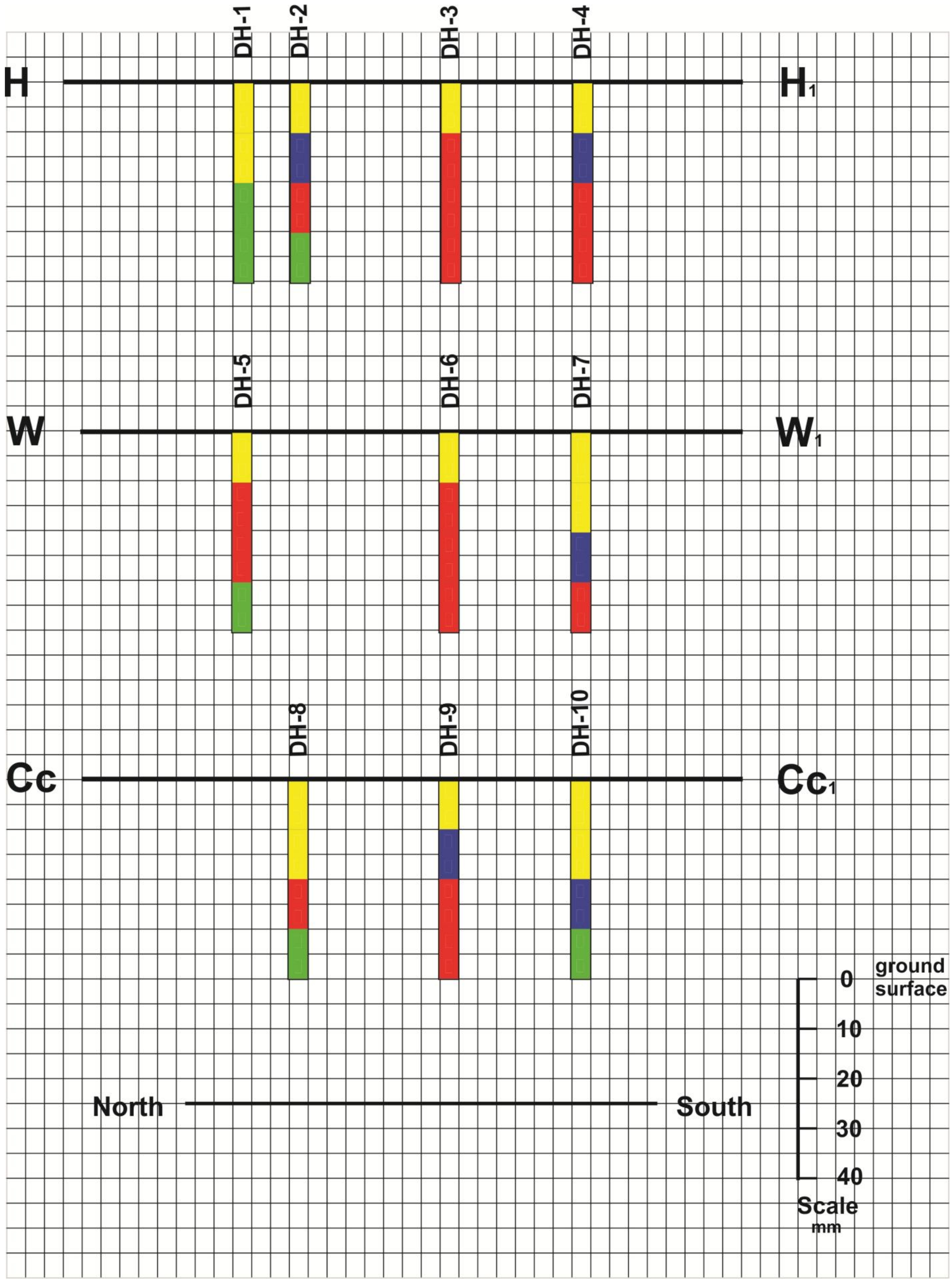
ORE DEPOSIT Section Location (Plan Map)

Number of Drill Holes:___

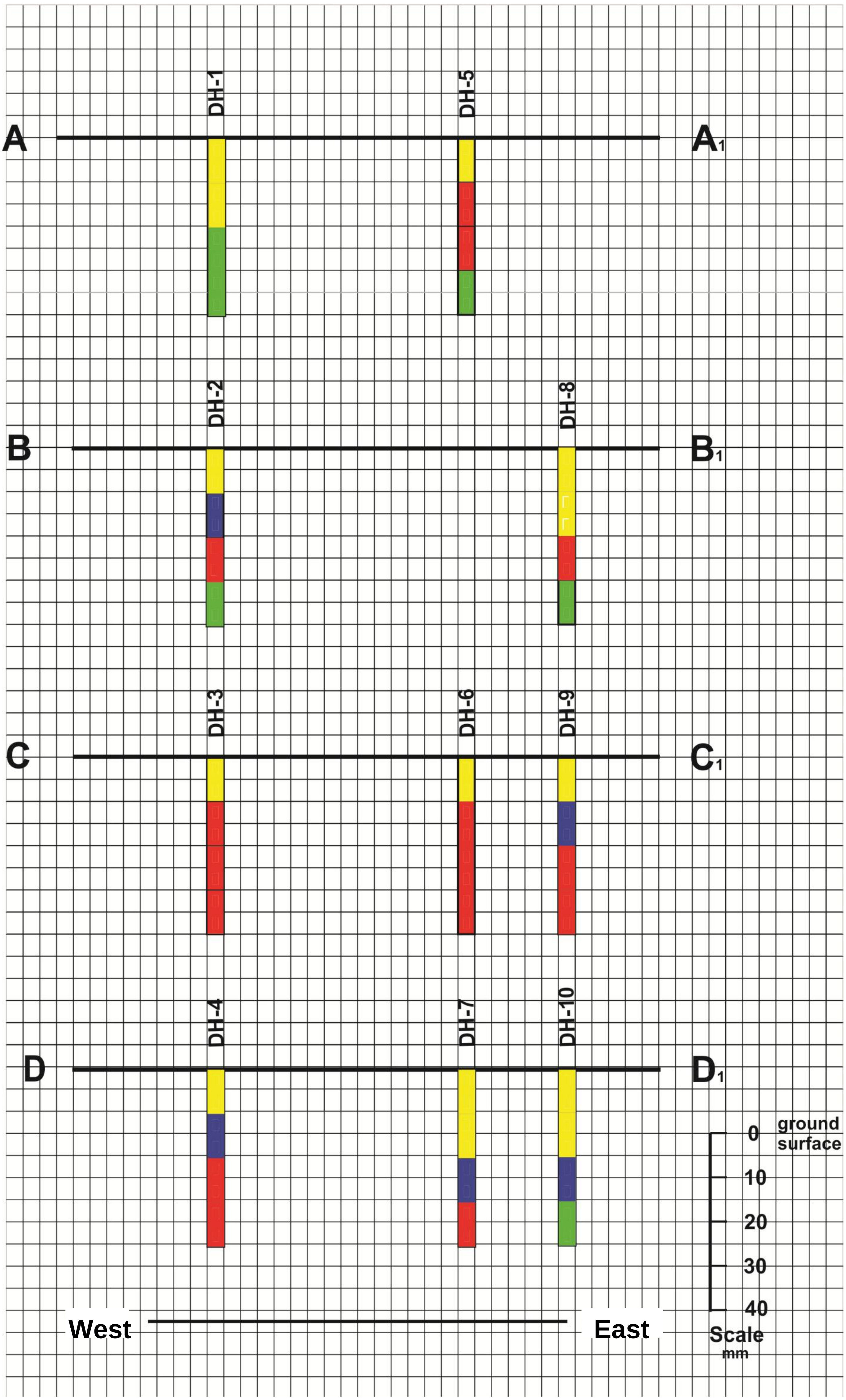


DRILL CORE EXAMPLE SECTIONS

North – South Sections (refer to ORE DEPOSIT Section Location)

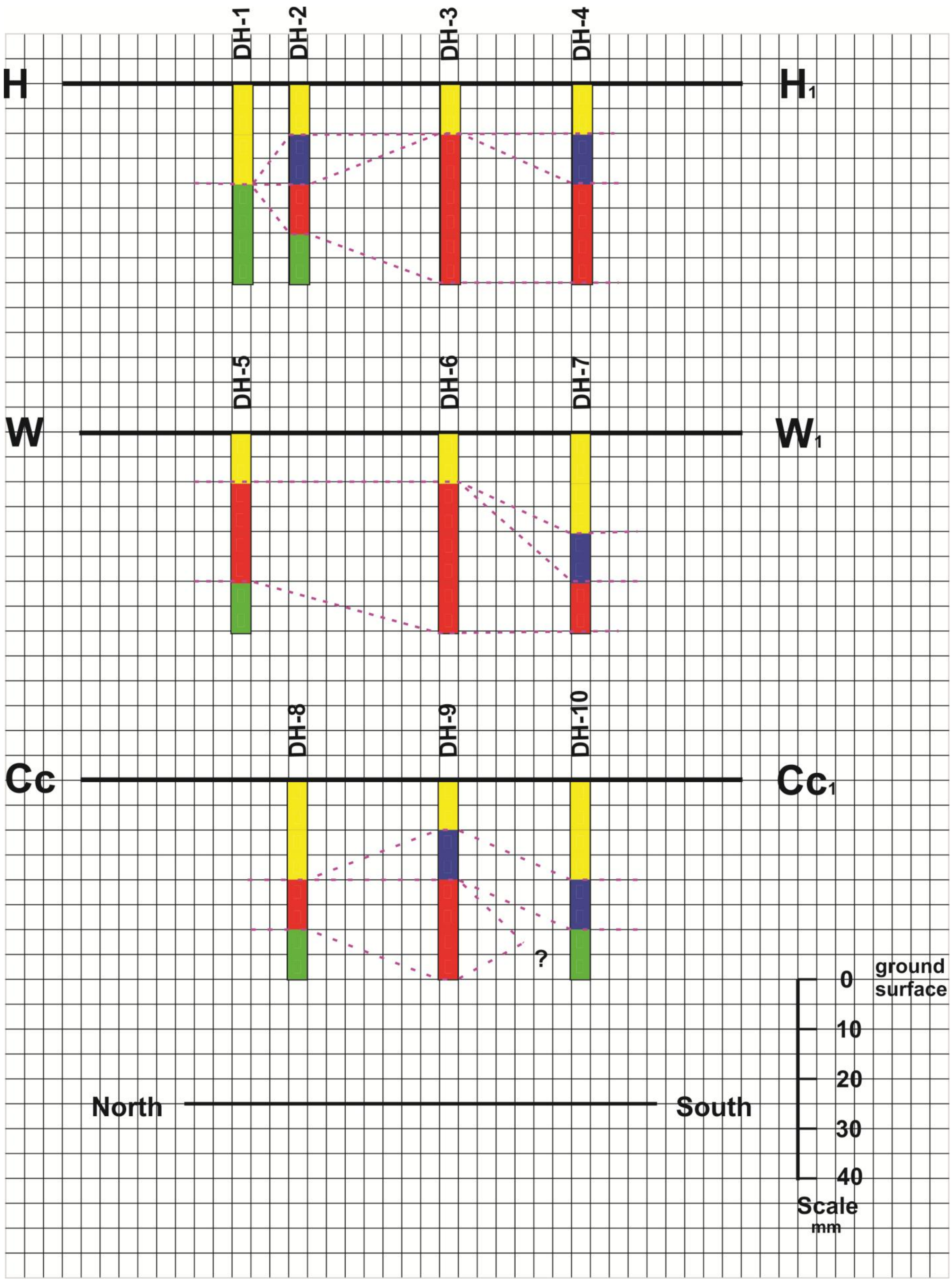


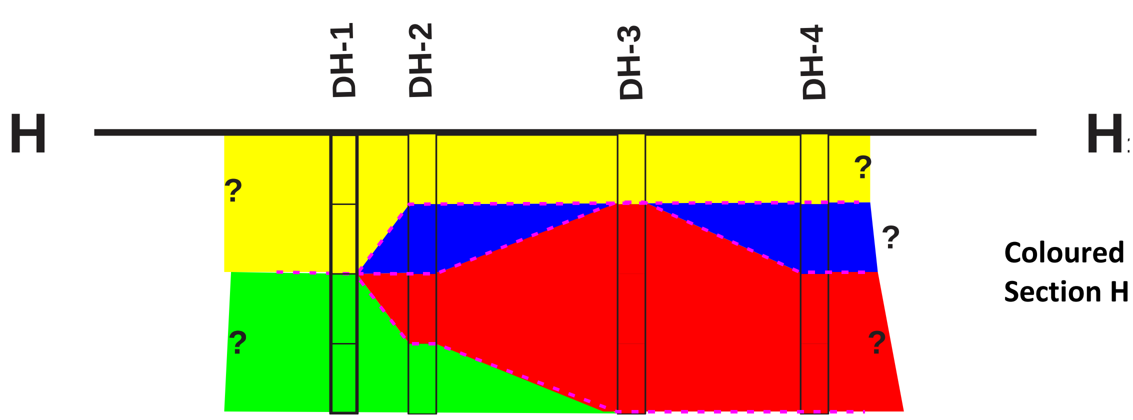
East – West Sections (refer to ORE DEPOSIT Section Location)



DRILL CORE EXAMPLE CORRELATION OF SECTIONS

North – South Sections (refer to ORE DEPOSIT Section Location)

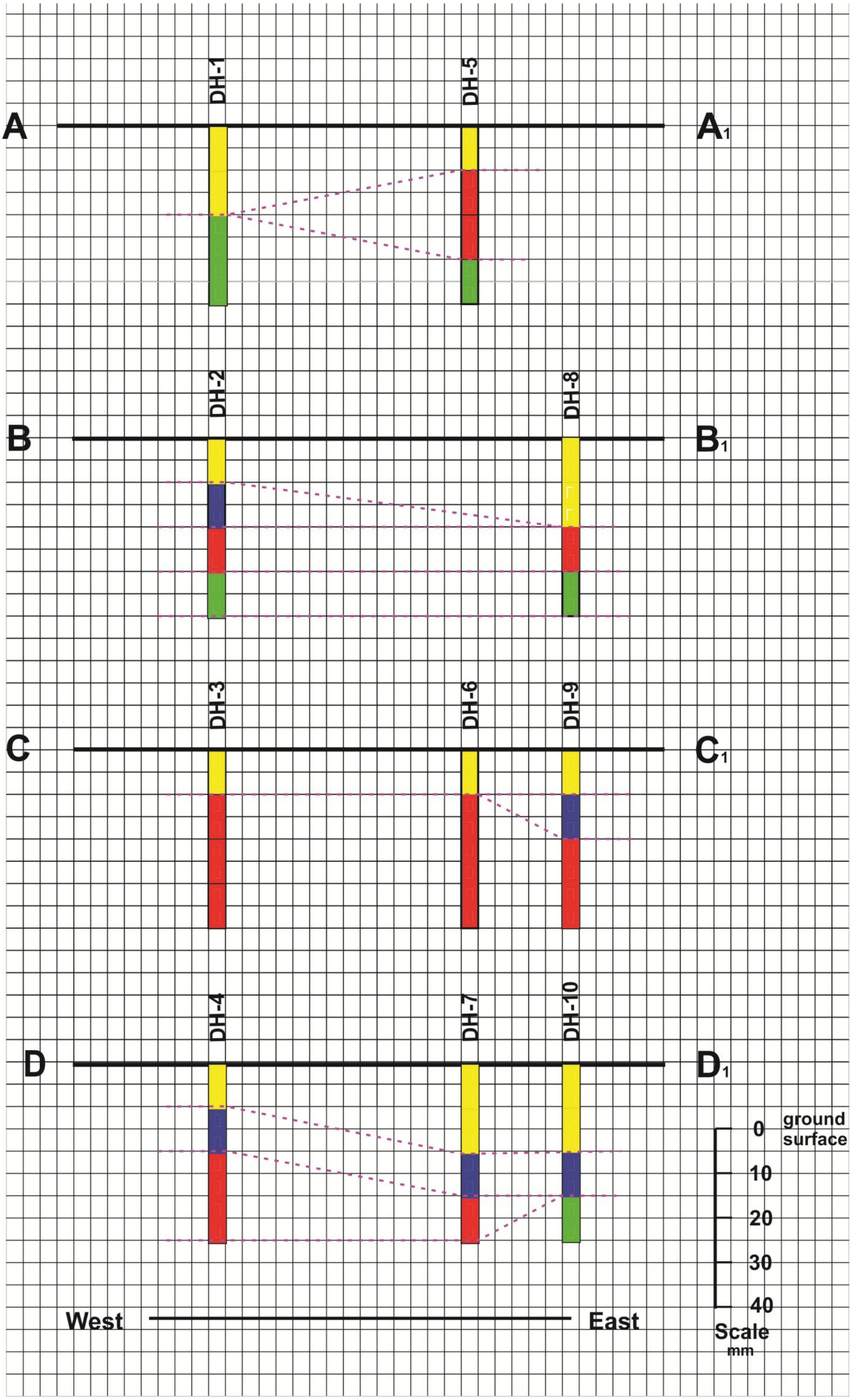




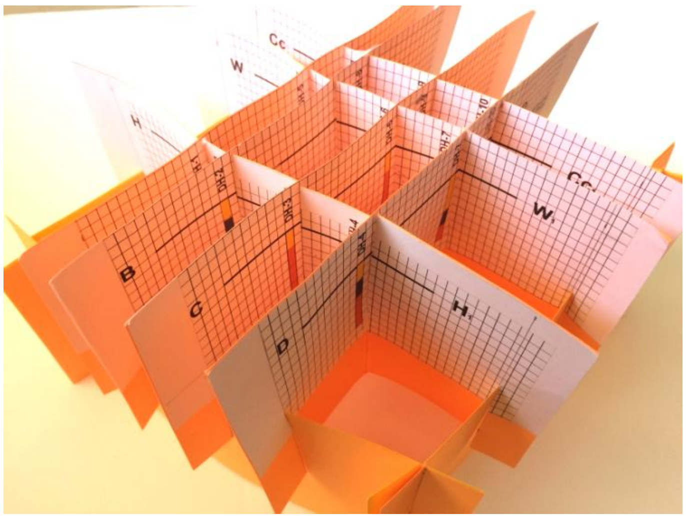
Coloured in Correlated Section H – H_1

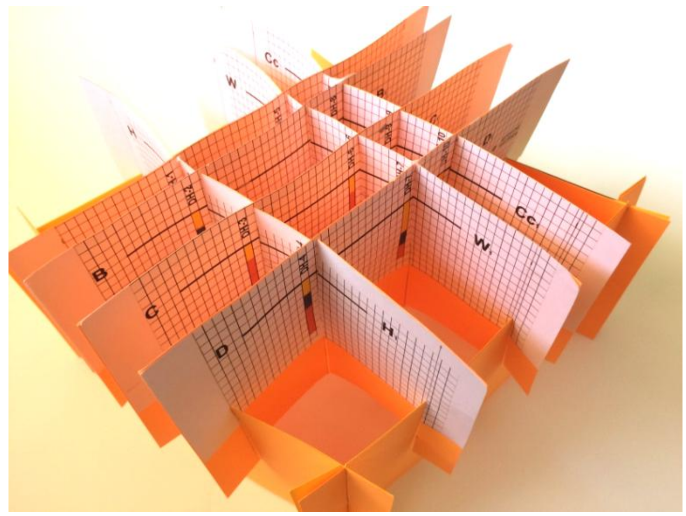
DRILL CORE EXAMPLE CORRELATION OF SECTIONS

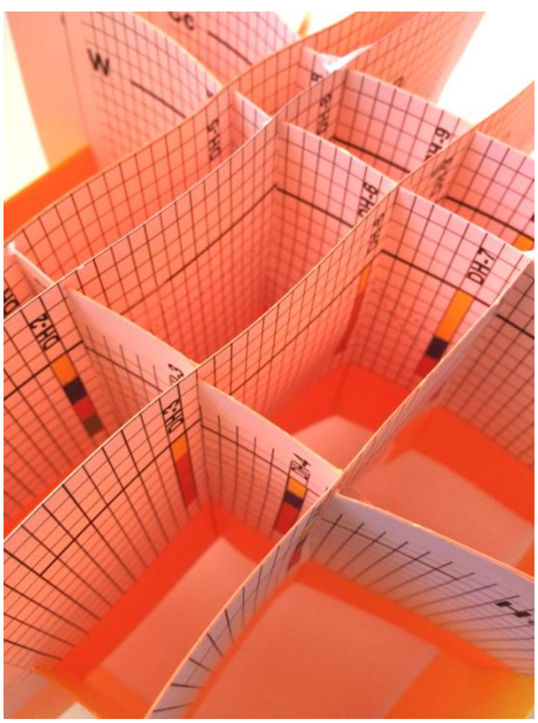
East – West Sections (refer to ORE DEPOSIT Section Location)

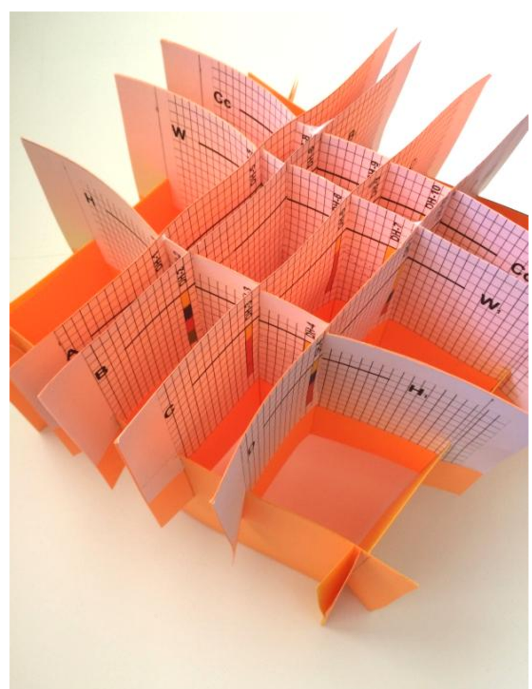


DRILL CORE 3D PAPER MODEL OF ORE DEPOSIT SECTIONS









Graph Paper